

Application No. 09/075,392
Amendment dated February 16, 2005

Amendments to the Specification:

Please replace the following amended paragraph beginning at page 4, line 11:

The invention also includes a method and apparatus for characterizing the thermal power output from the ~~thermal-electric~~ thermoelectric cooling devices to achieve linear temperature control and linear and non-linear temperature ramps.

Please replace the following amended paragraph beginning at page 4, line 16:

The invention also includes a method and apparatus for utilizing calibration diagnostics which compensate for variations in the performance of the thermoelectric devices so that all instruments perform identically. The thermal characteristics and performance of the assembly, comprised of the sample block, ~~thermal-electric~~ thermoelectric devices and heatsink, is stored in an on-board memory device, allowing the assembly to be moved to another instrument and behave the same way.

Please replace the following amended paragraph beginning at page 4, line 27:

Figure 2 is an enlarged, isometric view of a ~~thermal-electric~~ thermoelectric device constructed according to the invention.

Please replace the following amended paragraph beginning at page 5, line 18:

Figure 15 shows the sample block and a seal designed to protect the ~~thermal-electric~~ thermoelectric devices from the environment.

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Please replace the following amended title at page 8, line 19:

Peltier ~~Thermal-Electric~~ Thermoelectric Devices (TEDs)

Please replace the following amended paragraph beginning at page 9, line 16:

Using thin alumina layers in the ~~thermal-electric~~ thermoelectric device (of the order of 0.508 mm) not only reduces the thermal load but also means that for a given required heat pumping rate the temperature that the ends of the pellet reaches is reduced due to the increase in thermal conductivity k . This enhances reliability by reducing the thermal stress on the solder joint.

Please replace the following amended paragraph beginning at page 11, line 1:

If the thermal cyler was to be used as part of another instrument, e.g. integrated with detection technology, then it may be more convenient to use a different current source which would lead to a modified ~~thermal-electric~~ thermoelectric device geometry. The current source in the present embodiment consists of a class D type switch-mode power amplifier with a current sensing resistor in series with the device and ground.

Please replace the following amended paragraph beginning at page 11, line 6:

Because the ~~thermal-electric~~ thermoelectric devices are soldered together, excess solder can wick up the side of the bismuth telluride pellets. Where this occurs, k is increased which results in a local cold spot, also called a mild spot. These cold spots are reduced in number and severity by application of the minimum amount of solder during the assembly process of the ~~thermal-electric~~ thermoelectric device. For the same reason, it is also necessary to ensure that the solder used to attach

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the connecting wires to the ~~thermal electric~~ thermoelectric device does not contact the pellet.

Please replace the following amended paragraph beginning at page 11, line 18:

Figure 3 shows the ~~heatsink~~ heat sink 34 assembled with the thermoelectric devices 39 and the sample block 36. A locating frame 41 is positioned around the thermoelectric devices to align them with the sample block and the ~~heatsink~~ heat sink to ensure temperature uniformity across the sample block. The frame is composed of Ultem or other suitable material and has tabs 43 at its corners to facilitate handling. The ~~heatsink~~ heat sink 34 has a generally planer base 34 and fins 37 extending from base 35. The thermal mass of the heat sink is considerably larger than the thermal mass of the sample block and samples combined. The sample block and samples together have a thermal mass of approximately 100 joules/°K and that of the heat sink is approximately 900 joules/°K. This means that the sample block clearly changes temperature much faster than the heat sink for a given amount of heat pumped. In addition the heat sink temperature is controlled with a variable speed fan as shown in Figure 9. The temperature of the heat sink is measured by a thermistor 38 placed in a recess 40 within the ~~heatsink~~ heat sink and the fan speed is varied to hold the heat sink at approximately 45°C which is well within the normal PCR cycling temperature range, where maintaining a stable heat sink temperature improves the repeatability of system performance. When the block temperature is set to a value below ambient then the heat sink is set to the coolest achievable temperature to reduce system power consumption and optimize block thermal uniformity. This is accomplished simply operating the fan at full speed.

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Please replace the following amended paragraph beginning at page 12, line 11:

The ~~heatsink~~ heat sink temperature uniformity is reflected in the uniformity of the block temperature. Typically the ~~heatsink~~ heat sink is warmer in the middle than it is at the edges and this adds to other effects that lead to the corners of the block being the coldest. A trench 44 is cut into the heat sink outside the perimeter of the ~~thermal-electric~~ thermoelectric device area to limit the conduction of heat and decreases edge losses from the area bounded by the trench.

Please replace the following amended paragraph beginning at page 13, line 23:

The resulting even pressure distribution ensures that the full area of the ~~thermal-electric~~ thermoelectric devices is in good thermal contact with the block and the ~~heatsink~~ heat sink reducing local thermal stresses on the ~~thermal-electric~~ thermoelectric devices.

Please replace the following amended paragraph beginning at page 13, line 26:

Figure 4 shows other important features of the invention. A printed circuit board 82 includes a memory device 96 for storing data and surrounds the thermoelectric devices and provides electrical connections. Alignment pins 84 are seated in holes 86 in the ~~heatsink~~ heat sink and protrude through alignment holes 88 to align the printed circuit board with the ~~heatsink~~ heat sink. The locating frame 41 is positioned around the ~~thermal-electric~~ thermoelectric devices and has a cross beam 90 with a through hole 92. Pin 24 (shown in Figure 1) fits into a hole (no shown) in the sample block, extends through hole 92 in the locating frame and further extends into hole 94 in the ~~heatsink~~ heat sink.

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Please replace the following amended paragraph beginning at page 21, line 21:

The control software includes calibration diagnostics which permit variation in the performance of thermoelectric coolers from instrument to instrument to be compensated for so that all instruments perform identically. The sample block, ~~thermal-electric~~ thermoelectric devices and ~~heatsink~~ heat sink are assembled together and clamped using the clamping mechanism described above. The assembly is then ramped through a series of known temperature profiles during which its actual performance is compared to the specified performance. Adjustments are made to the power supplied to the ~~thermal electric~~ thermoelectric devices and the process is repeated until actual performance matches the specification. The thermal characteristics obtained during this characterization process are then stored in a memory device residing on the assembly. This allows the block assembly to be moved from instrument to instrument and still perform within specifications.

Please replace the following amended paragraph beginning at page 22, line 12:

This embodiment automates the actual measurement using a feedback control system and eliminates the need to remove the ~~thermal-electric~~ thermoelectric device from the unit. The control system compensates for the temperature difference between the two surfaces of the thermoelectric device caused by the heat sink attached to one side and the sample block attached to the other. The control system causes the thermoelectric device to equalize its two surface temperatures and then the AC resistance measurement is made. The micro-controller performs a polynomial calculation at the referenced time of the AC measurement to compensate for ambient temperature error.

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Please replace the following amended paragraph beginning at page 22, line 20:

Figure 9 shows the sample block 36, a layer of ~~thermal-electric~~ thermoelectric device 60 and ~~heatsink~~ heat sink 34 interfaced with the system microcontroller 62 and bipolar power amplifier 64. The temperature sensor is already present in the ~~heatsink~~ heat sink 38 and an additional temperature sensor attached to the sample block 36 with a clip (not shown) formed of music wire are utilized to determine the temperature differential of the surfaces of the ~~thermal-electric~~ thermoelectric device.

Please replace the following amended paragraph beginning at page 22, line 26:

The bipolar power amplifier supplies current in two directions to the device. Current in one direction heats the sample block and current in the other direction cools the sample block. The bipolar power amplifier also has signal conditioning capability to measure the AC voltage and AC current supplied to the ~~thermal-electric~~ thermoelectric device. A band pass filter 68 is incorporated into the signal conditioning to separate an AC measurement signal from the steady state signal that produces a null condition for the temperature difference across the ~~thermal-electric~~ thermoelectric device.

Please replace the following amended title at page 23, line 23:

Sealing the ~~Thermal-Electric~~ Thermoelectric Device Area from the Environment.

Please replace the following amended paragraph beginning at page 23, line 14:

The ~~thermal-electric~~ thermoelectric devices are protected from moisture in the environment by seals and the chamber is kept dry with the use of a drying agent such as silica gel. The seal connects from the silver electroform to the surrounding support and as such adds to the edge losses from the

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block. These losses are minimized by the use of a low thermal conductivity pressure seal 98 and by the use of the perimeter heater described above. The seal 98 has a cross-section generally in the shape of a parallelogram with several tabs 100 spaced about the lower surface of seal 98 for holding seal 98 to the edge of the sample block as shown in Figure 15.